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Improved inverter performance and renewable charging stations with battery swapping technique for electric vehicles

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ABSTRACT

Automobiles have become a global common denominator. The hindrance with using automobile is that most of them operate with the help of fossil fuels. Exploitation of natural resources is increasing due to the demand for personal automobiles. This will cause a severe and potentially cataclysmic problem to our planet. To create a change in the global human behavior towards a more sustainable future we need to make intelligent choices for the next generation electric drive technology. By integrating Li – ion battery with solid state batteries we can achieve an efficient source with fast charging ability. A new charging station which is completely renewable will be erected for charging vehicles. With DC charging, more power can be delivered to the battery. Battery Management System (BMS) can be used to limit the peak voltage during charging and prevents cell voltage from dropping below threshold during discharging. In this we have proposed 7 level cascaded h bridge multilevel inverter topology to obtain nearly sinusoidal waveform to improve the performance and efficiency of induction motor fed electric vehicle drive system.

Keywords: Renewable energy, Li-ion battery, Battery swapping, Multilevel inverter, Regenerative braking, Induction motor

1. INTRODUCTION

Automobile has become a universal language that every human can relate to somehow but it also shapes and influences people lives one way or another. To create a change in the global human behavior towards a more sustainable future, we need to modernize the one thing that has been the symbol of the industrialized world for over a hundred years. The automobile has become the platform and the standard that forms most people's perception of the modern technology. In order to recalibrate this notion and achieve a sustainable revolution the concept of electric vehicles were introduced.

2. BATTERY TECHNOLOGY

Li-ion cells of nominal voltage 3.2 V each connected in series - parallel combination to form a battery pack. The chemistries of each battery is based on life span, performance, safety, specific energy, specific power. Out of all the Li-ion chemistries (Fig.1.) only LFP (Lithium - Iron - phosphate) is found to be superior in all aspects. The life span and safety of LFP is very high. The ability to deliver power to motor by LFP is also very good. So it is very advantageous to use LFP battery. Life Span reflects cycle count and longevity. The Li-ion batteries almost doesn't require any maintenance in its life time. Mostly batteries of electric vehicles are guaranteed for 8–10 years for 160,000 km. Li – ion batteries have low self-discharge.

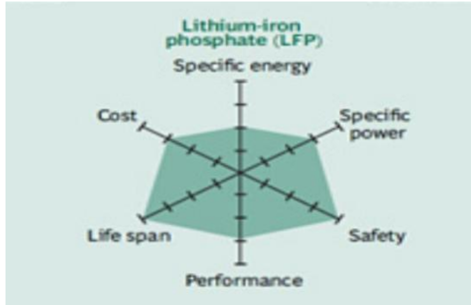


Fig.1. LFP Chemistry

The alternate source used here is solid state battery. The solid state batteries uses the solid electrolyte. The solid state batteries have the following advantages: Faster charging, increased energy density, increased cycle life, Low leakage currents, Non flammability. The recovery of kinetic energy has also been added. During braking more amount of kinetic energy will be produced in the shaft. This kinetic energy can be recovered and converted into electrical energy with the help of ESU (Energy Storage Unit). ESU consists of some power electronic devices to convert kinetic energy into electrical energy. The regenerative braking doesn't work when the SOC is more than the certain limit. Here when the SOC of LFP is more than 70%, kinetic energy cannot be recovered.

3. BATTERY MANAGEMENT SYSTEM

Battery Management System [1] shortly mentioned as BMS. Technically speaking, BMS is not required. But if we are speaking on the safety side, BMS is required. Li-ion cells are safe if they are operated within their safe operation area (SOA). BMS helps la Li-ion cells to operate in SOA (i.e.) to maintain temperature, current and voltage. Its second function is it equally charges all the cells. It will almost prevents the cell from discharging below threshold voltage. The BMS can communicate with the user and connected equipment and controls safety related elements. The difference between analog BMS and digital BMS is, analog BMS doesn’t know where to use and how to check whether the battery gets charged or not. So a digital battery management system (BMS) is used here.

The architecture in Fig.2 is an example for 12 V supply.

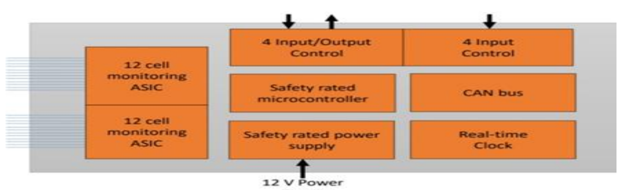


Fig.2. Architecture of BMS

4. CHARGING STATION

The other important aspect we are concentrating is charging station for an electric vehicle (Fig.3). Our charging station is completely by renewable energy. The battery packs here are charged using solar and wind energy. The radiations produced by the sun, the radiations reflected off the ground and from the area surrounding the solar panels are being collected by the solar panels. The angle of the sun is not constant, it varies throughout the year. Therefore, the optimal tilt angle for a PV panel in the winter compared to summer will differ. This angle will also vary by latitude. A nominal voltage of 12V PV panel has been installed. And Wind energy is also been used. This is nothing but the charging station is completely a renewable one.

The Li-ion battery of different capacities will be charged in the charging station. Vehicles with different capacities can swap their batteries with the batteries available in the charging station. This is battery swapping method [2].

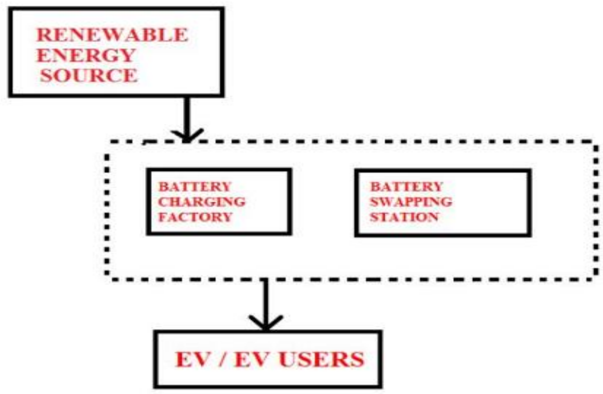


Fig.3. Charging station layout

5. INDUCTION MOTOR

The motor we use here is Induction motor, the induction motor is used because it is highly robust, light weight, cheap induction machines have no magnets and B fields are "adjustable," since B is proportionate to V/f (voltage to frequency). At light loads the inverter can be able to reduce voltage that the magnetic losses are reduced and efficiency is maximized. Thus, the induction machine when operated with a smart inverter has an advantage over a DC brushless machine – magnetic and conduction losses can be traded such that efficiency is optimized. This advantage becomes increasingly important as performance is increased. With DC brushless, as machine size grows, the magnetic losses increase proportionately and part load efficiency drops. With induction, as machine size grows, it is not necessary that the losses should grow. Thus, induction drives may be the favored approach where high-performance is desired; peak efficiency will be a little less than with DC brushless, but average efficiency may actually be better. Induction drives is dominant due to its high-performance.

6. INVERTER

The circuit in Fig.4 shows the conventional inverter fed electric vehicle drive. The output from the conventional inverter will be a quasi square sine wave output which is a high level of harmonic content. When sine wave of high harmonic content is fed to the motor it will produce high amount of losses in the form of heating, which leads to reduction of motor performance in terms of efficiency, torque, speed and even leads to damage of motor windings. The motor performance can be improved by reducing the total harmonic distortion in the sine wave output from the inverter fed to motor of electric vehicle drive. In order to get nearly sine wave output from the inverter, Multilevel inverter topology is modelled[3]. Here improved cascades H bridge seven level multilevel inverter topology is used to feed the Induction motor operated electric vehicle is proposed.

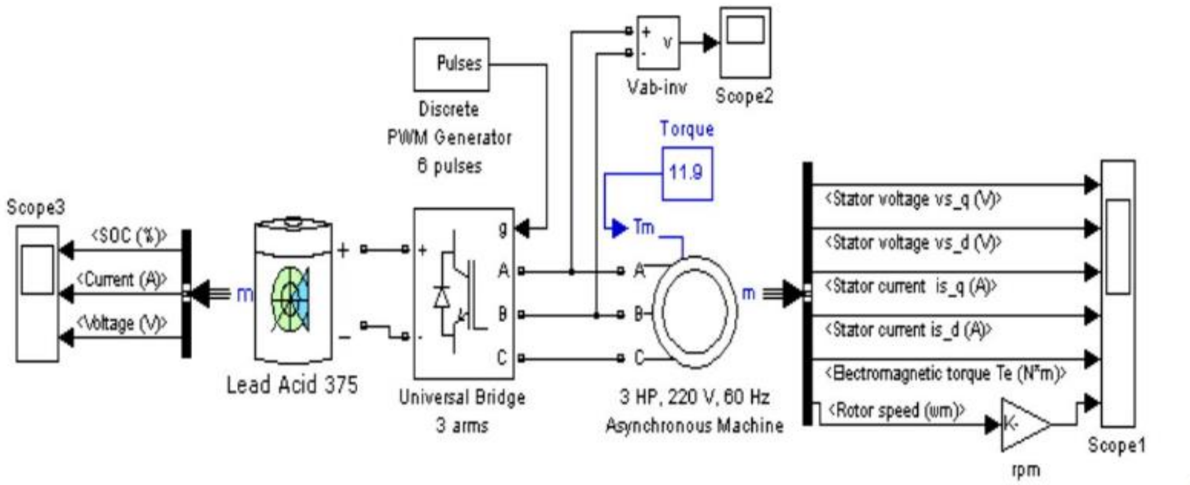


Fig.4. EV with conventional inverter

The Fig.5 shows the seven level cascaded h bridge multilevel inverter topology. The input to the inverter is fed from a DC source Li-ion Battery. The seven level output from the inverter is fed to the Induction motor which drives the electric vehicle. By using this improved topology of inverter harmonic content in the inverter output gets reduced, so that the motor performance gets improved. The overall efficiency of the electric drive system gets improved.

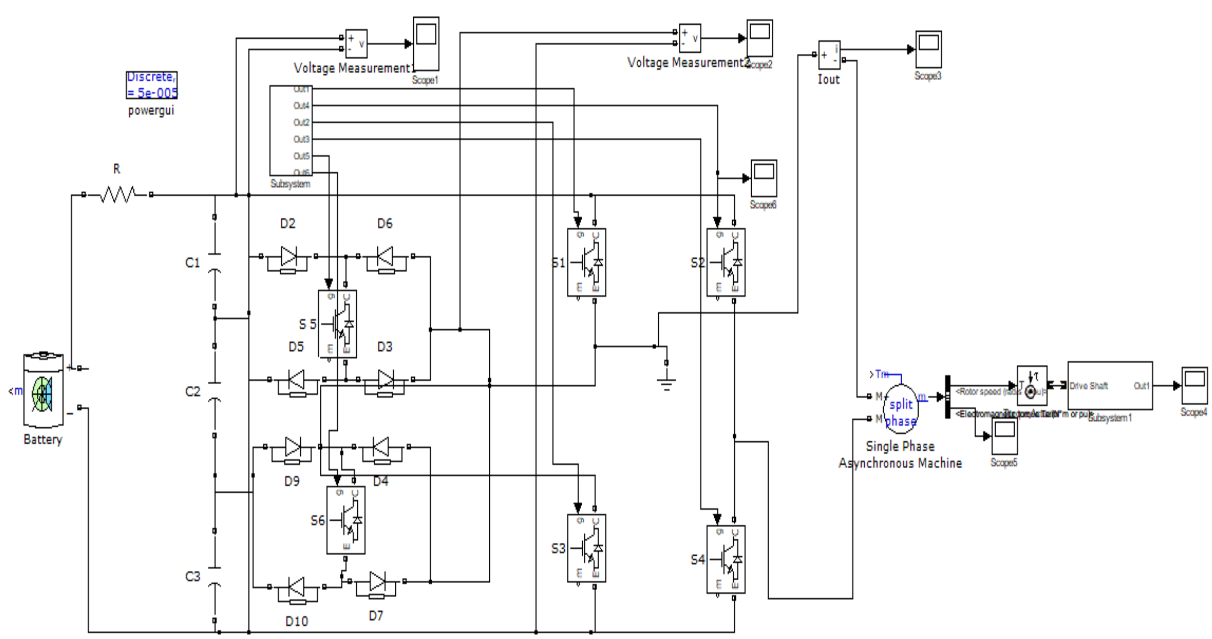


Fig.5. EV with multilevel cascade H bridge inverter

7. RESULTS

General output waveform of multilevel cascade H bridge inverter is shown in Fig.6.

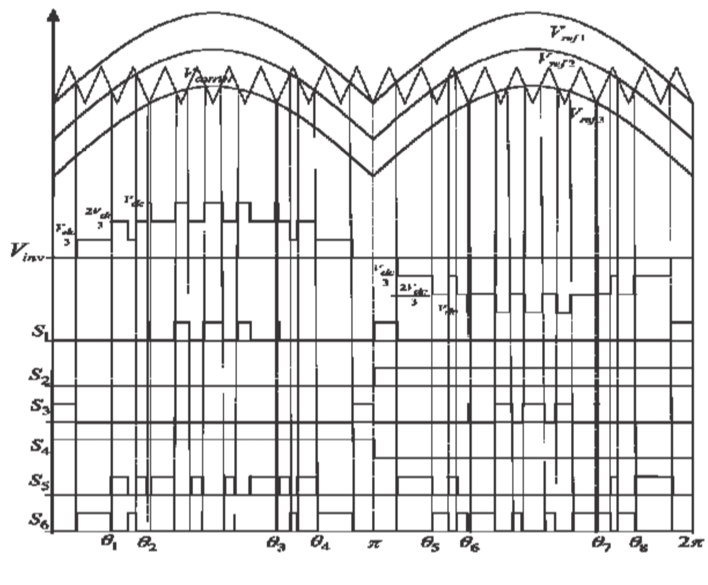
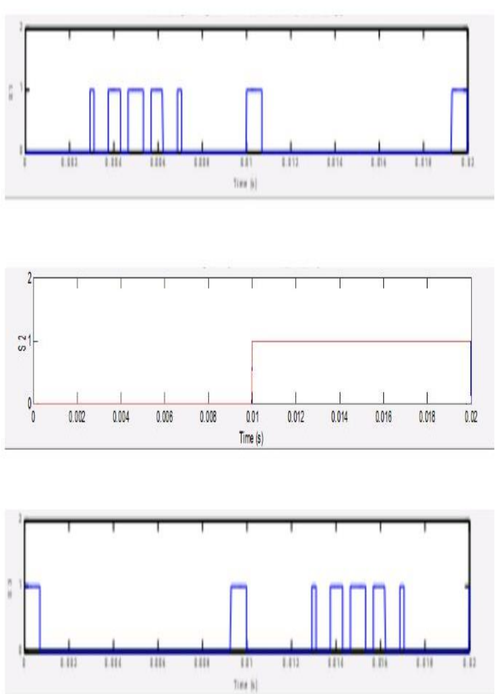


Fig.6. Multilevel cascade H bridge inverter output waveform

The gate pulse for multilevel cascade H bridge inverter for S1 to S6 is shown in Fig.7.1 and Fig 7.2.



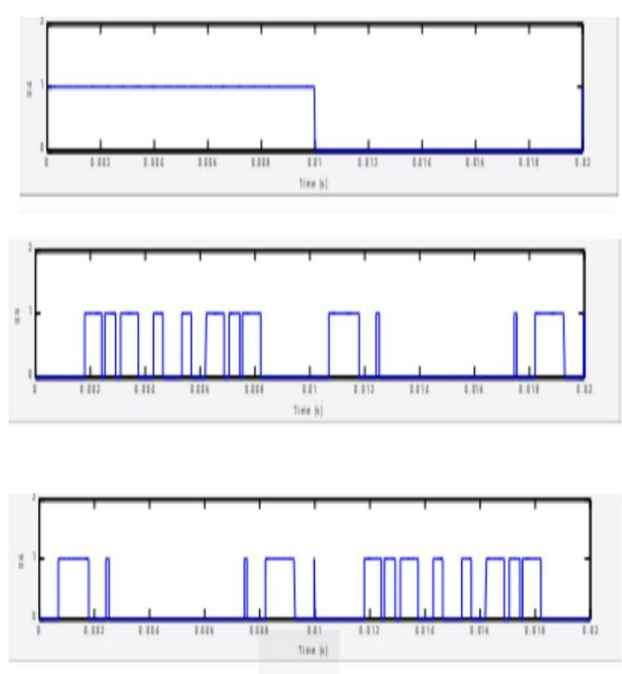


Fig.7.1. Gate pulse for S1, S2, S3

Fig.7.2.Gate pulse for S4, S5, S6

The output voltage waveform of multilevel cascade H bridge inverter is shown in Fig.8. The Total Harmonic Distortion for multilevel cascade H bridge inverter is 21.76% and the modulation index is found to be 0.9.

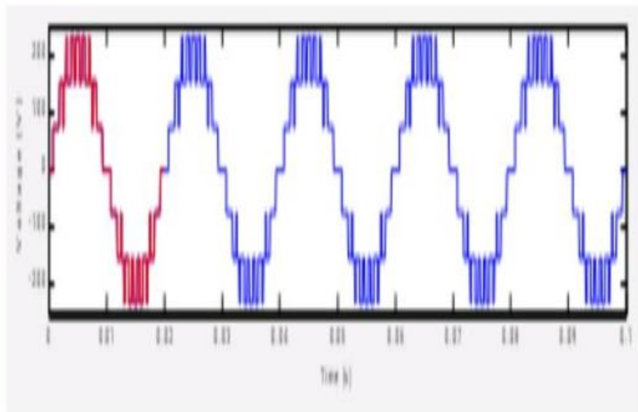


Fig.8.Output voltage waveform of multilevel cascade H bridge inverter

By using multilevel cascade H bridge inverter, torque and speed characteristics improved which is shown in Fig.9.1 and Fig.9.2.

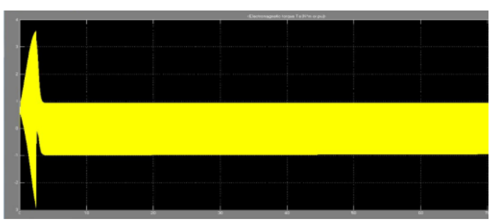


Fig.9.1. Torque characteristics of EV using multilevel inverter

Fig.9.2. Speed characteristics of EV using multilevel inverter

The main advantages of multilevel inverter over conventional inverter are:

Conventional inverter	**Multilevel cascaded h bridge inverter**
No soft switching	Soft switching is there
It is difficult to obtain for multiple level of source	It can be obtained for multiple level of sources
Pure sine wave is not obtained	Almost pure sine wave is obtained
Harmonics are more	Harmonics are reduced
Works in low switching frequency	Works both in high and low switching frequency
Not able to interface with renewable energy resource	Easily interfaced with renewable resources
Input current is drawn with distortion	Low battery current is drawn without distortion
It does not produce common mode voltage	It produces common mode voltage ,reducing the stress of the motor

8. CONCLUSION

A cost effective simplified modified H bridge seven level multilevel inverter for electric drive system has been developed and simulated in matlab. By using multilevel inverter combined with PWM technique, the harmonic content in the output gets reduced and fundamental component gets increased. So that the motor performance and the overall performance of the Electric Vehicle drive system gets improved. The future work focuses on implementation of MLI with more number of power switches combined with effective battery management system and battery swapping technique in charging stations.

REFERENCES

1. Rui Hu ,"Battery management system for electric vehicle applications", University of Windsor,2011.

2. Sujie Shao , Shaoyong Guo and Xuesong Qui ,"A mobile battery swapping service for electric vehicle based on a battery swapping van", MDPI energies article, State key Laboratory of Networking and Switching Technology, Beijing University of posts and Telecommunications

3. Schaltz and Erik, "Electrical vehicle deign and modelling",Aalborg University,Denmark,2011.

4. Elena Villanueva, Pablo Correa, Jose Rodriguez, Mario Pacas, “Control of Single-Phase Cascaded H-Bridge Multilevel Inverter for Grid-Connected Photovoltaic Systems,” IEEE Trans. Ind. Electron., vol. 56, no. 11, pp.4399-4405, November 2009.

5. Rahim. N.A, Elias M.F.M, Wooi Ping Hew, “Transistor Clamped H-Bridge Based Cascaded Multilevel Inverter With New Method of Capacitor Voltage Balancing,” IEEE Trans. Ind. Electron., vol. 60, No. 8, pp. 2943-2956, July 2013.

6. Malinowski, Mariusz et al,”A survey on cascaded multilevel inverters,” IEEE Trans. Ind. Electron., vol. 57, no. 7, pp. 2197–2206, July 2010.

7. Rodriguez. J, Lai J.S, and Peng. F.Z, “Multi-Level inverter: a survey of topologies, control, and application,” IEEE Trans. Ind. Electron. vol.49, no. 4, pp.724-738, August 2002.

8. Zedong Zheng, Kui Wang, Lie Xu, and Yongdong Li, “A Hybrid Cascaded Multilevel Converter for Battery Energy Management Applied in Electric Vehicles,” IEEE transactions on power electronics, vol. 29, no. 7, pp.3537-3546, July 2014.

9. Stand alone inverter for photovoltaic systems,” bonfiring transactions on power systems and integrated circuits, vol. 2, special issue 1, Part I, pp.49-53,2012.